

AIAA  
93-0585



A93-23316

**AIAA 93-0585**  
**NASA Scientific and Technical**  
**Information Program**  
**Multimedia Initiative**  
G. Cotter and K. Kaye  
NASA Headquarters  
Washington, D.C.

**DISTRIBUTION STATEMENT A**  
Approved for public release  
Distribution Unlimited

AIAA 93-0585

REC'D  
JAN 27 P 3:49

RECEIVED  
LIBRARY

PLEASE RETURN TO:

BMD TECHNICAL INFORMATION CENTER  
BALLISTIC MISSILE DEFENSE ORGANIZATION  
7100 DEFENSE PENTAGON  
WASHINGTON D.C. 20301-7100

19980309 401

DTIC QUALITY INSPECTED

**31st Aerospace Sciences**  
**Meeting & Exhibit**  
January 11-14, 1993 / Reno, NV

For permission to copy or republish, contact the American Institute of Aeronautics and Astronautics  
370 L'Enfant Promenade, S.W., Washington, D.C. 20024

U4488

Accession Number: 4488

Publication Date: Jan 11, 1993

Title: STI Program Multimedia Initiative

Personal Author: Cotter, G.A.; Kay, K.

Corporate Author Or Publisher: AIAA, 370 L'Enfant Promenade, SE, Washington, DC 20024 Report Number: AIAA-93-0585

Comments on Document: Paper presented at the 31st Aerospace Sciences Meeting & Exhibits of the AIAA, Reno, Nevada.

Descriptors, Keywords: NASA Scientific Technical Information Multimedia Program STI Image Document

Pages: 00008

Cataloged Date: May 21, 1993

Document Type: HC

Number of Copies In Library: 000001

Record ID: 26827

STI PROGRAM MULTIMEDIA INITIATIVE

Gladys A. Cotter  
 Scientific and Technical Information Program Director  
 Karen Kaye  
 Multimedia Initiative Project Manager  
 National Aeronautics and Space Administration  
 Scientific and Technical Information Program  
 Washington, DC 20546

A93-23316

Abstract

This paper relates the experience of the NASA Scientific and Technical Information Program in introducing multimedia within the STI Program framework. A discussion of multimedia technology is included to provide context for the STI Program effort. The STI Program's Multimedia Initiative is discussed in detail. Parallels and differences between multimedia and traditional information systems project development are highlighted. Challenges faced by the program in initiating its multimedia project are summarized along with lessons learned. The paper concludes with a synopsis of the benefits the program hopes to provide its users through the introduction of multimedia illustrated by examples of successful multimedia projects.

STI Program Multimedia Initiative

NASA's Scientific and Technical Information (STI) Program is responsible for providing "the widest practicable and appropriate dissemination" of information concerning NASA activities and research results. However, the current STI Program is based upon a technology infrastructure assembled in the mid 1960's to late 1970's. Today, the Program's customers within NASA are utilizing multimedia in documenting their scientific and technical endeavors. Thus, faced with the need to continue to serve the aerospace community in today's information environment, NASA's STI Program is currently revamping its products and services to keep pace with technology. The STI Program Multimedia Initiative is representative of the Program's re-engineering effort.

Background

Since multimedia has become the computer buzzword of the 1990's, most people have heard about multimedia, but not everyone has a clear idea of what constitutes a multimedia presentation or what benefit

can be gained through the use of multimedia. The NewMedia magazine information visionaries have summarized multimedia's impact in the following terms: "Today the power to fundamentally change the way we communicate and learn is at our fingertips. Multiple media - text, graphics, sound, and motion - have been integrated through digital technology to deliver a communication experience that dramatically alters the way people give and receive information." They go on to emphasize the "dawning of the age of multimedia - for the people and by the people. In business, government, education, and social realms, tremendous breakthroughs in communication and interactive information retrieval are being achieved every day." 4

There is no shortage of commentary on how multimedia will revolutionize our existence. The potential impact of multimedia has been compared individually to that of the personal computer, the television and the printing press. IBM has called multimedia a revolution in communications that combines the audiovisual power of television, the publishing power of the printing press and the interactive power of the computer. Intel has called multimedia the marriage of the personal computer and the television that will result in a system that is as realistically visual and easy to use as TV, with all the responsiveness and processing capability of today's most powerful desktop computers. Intel goes on to say that multimedia represents a new communications medium that will dramatically affect how we process and use information, and multimedia also represents a major business opportunity for those prepared to embrace the technology and deliver it into the hands of the users.

In fact, multimedia technologies have recently converged at a price point that makes multimedia a realistic option for scientific, technical and engineering information presentation. In acknowledging the ever-increasing use of multimedia for the presentation of information, the STI Program is working to integrate

This paper is declared a work of the U.S. Government and is not subject to copyright protection in the United States.

PLEASE RETURN TO:

BMD TECHNICAL INFORMATION CENTER  
BALLISTIC MISSILE DEFENSE ORGANIZATION  
DISTRIBUTION STATEMENT

multimedia technologies into its products and services. Within NASA, multimedia information presentation is needed to adequately deliver scientific and technical information that is rich in pragmatic content. The pragmatic information aspects might include items such as data, computer models, scientific visualizations, software, a video record of an experiment, formulae, text, and graphics. Key to adequate delivery of such information is its integration into a unified multimedia whole from which the user can easily get the information wanted in the form wanted. Thus, the most obvious benefit to multimedia information presentation is the ability to deliver information in its most effective format so that there are no barriers to information understanding.

### Terminology

In 1978, Nicholas Negroponte, a scientist at MIT's Media Laboratory, envisioned the fusion of the broadcast, print publishing, and computer industries as the direction of future communication. Since then the information industry has loosely used the term multimedia to refer to those often computer-driven applications having a user interface allowing access to unified content including video, audio, photographic images, graphics, numbers, and text. By this definition, early television, which did not employ computer technology

and whose origin predated that of multimedia, could correctly be described as multimedia. The distinction most often made between older technologies like television and current-day multimedia takes into account the fact that multimedia applications can be classified into several types based upon the user's level of interaction with the application. In this way, one realizes that the more advanced forms of multimedia, which allow greater user interaction, require computer support. These computer-supported applications, listed as the interactive and participative application types in Table 1, are those that are most often thought of as multimedia.

Table #1

Application Type	User Interaction	Example
Narrative	Watch & listen	Television
Interactive	Choose & do	Columbus
Participative	Contribute & create	British Film Institute

Although the above definitions are precise enough to distinguish between types of multimedia applications, some confusion remains because multimedia and other terms such as hypermedia, intermedia, and

Table #2

Umbrella Project STI Program Multimedia Initiative Focus: Coordination & tracking of multimedia activities Future: Information set on NASA STI Program multimedia projects		
Subproject Non-print  Focus: Handling and dissemination of non-print  Future: In-house reproduction facility for multiple formats	Subproject Global Change  Focus: Grade 13 and above interactive multimedia presentation of NASA Global Change Data and Information (Prototype)  Future: Joint Government/ Industry project	Subproject Performance Support System  Focus: Provide multimedia performance support at the desktop for STI staff  Future: Provide multimedia performance support at the desktop for NASA scientists in a specific discipline

interactive multimedia are often used interchangeably, even though an argument can be made to differentiate the terms based upon their original meaning. For instance, hypermedia was originally thought of as a subset of multimedia that was defined by the presence of a nonhierarchical, nonlinear link structure.<sup>6</sup> Brown University's Institute for Research in Information Scholarship (IRIS) multi-user "hypermedia" system was named "Intermedia." Interactive multimedia originated in the interactive videodisc field as an interactive training term. Interactive was used to indicate that the application responds in real time to the user's direction. Although the term "multimedia" is used more often than the other terms, the 1993 Microsoft International Conference on Multimedia and CD-ROM will be called "Intermedia."

### The Project

The STI Program Multimedia Initiative is a user-driven umbrella project that currently includes three subprojects. The subprojects are the Non-print Project, the Global Change Project and the Performance Support System. Project relationships and objectives are spelled out in Table 2. All three projects address STI Program areas that can be re-engineered at reasonable cost through the introduction of multimedia to provide needed services to the user community.

The STI Program Multimedia Initiative will provide the mechanism for the coordination and tracking of STI Program multimedia activities. The Multimedia Initiative Project has been defined to support the following STI Program strategic planning goals:

- Expand participant community.
- Improve current operations.
- Become integral to NASA Research & Development.<sup>1</sup>

In addition, the Multimedia Initiative recognizes these objectives:

- Verify the economic and technical feasibility of delivering multimedia information within the STI Program framework.
- Make a positive educational and informational impact.
- Develop an exploitable capability.

All of the Multimedia Initiative projects must follow standard top-down information project development procedures beginning with a design phase which includes user requirements. However, in addition to the programming and testing and documentation phases common to information systems projects, the

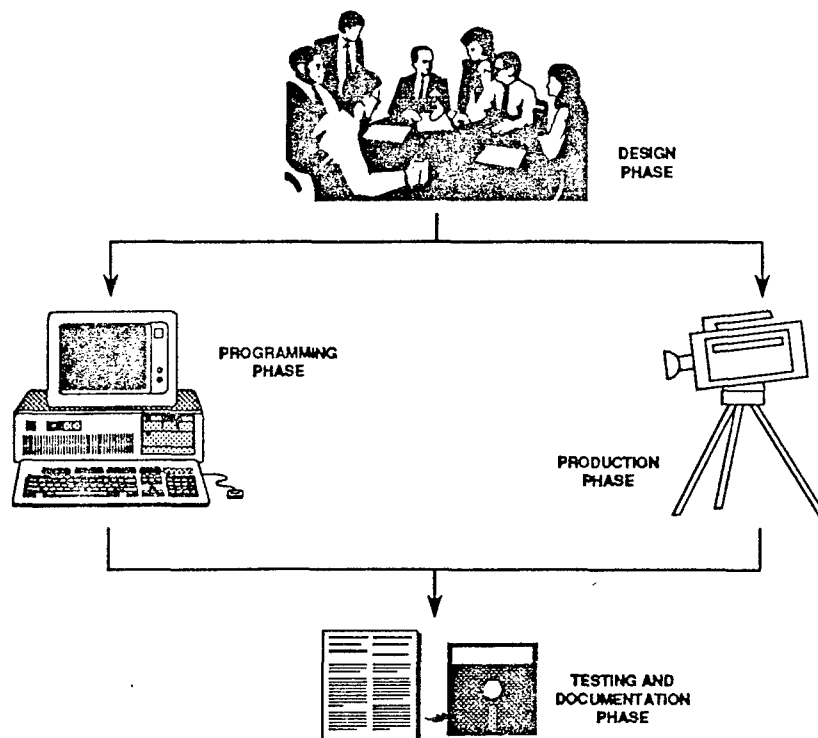


Figure 1. Phases of Multimedia Application Development

multimedia content may necessitate a production phase during which audio and video are produced or collected.

During the design phase, major factors affecting design decisions are analyzed including target audience, setting, and subject. It is in this design phase that the problems involved in current attempts to convey the information are addressed in terms of how multimedia can solve the communication problem. The setting or where the application will be used is also addressed in terms of where and for how long users are likely to interact with the application. During this stage, a front-end analysis document that is similar to a requirements analysis document is produced to guide design decisions. The subject of the application determines the content and drives some of the design decisions such as the resolution necessary for images or the quality level of the audio.

The programming, testing, and documentation phases of application design can follow information system development procedures. In addition, the same production procedures used by the video industry may be needed for the video component of the multimedia application. Since storyboarding, shooting, and editing of video material is alien to most information system specialists, the multiple types of media that must be produced and integrated into a multimedia application necessitate the cooperation of a project development team with expertise from different disciplines.

#### Accomplishments to Date

Although the STI Program Multimedia Initiative Project Plan was written in June of 1991, the project lost an initial battle for scarce program resources resulting in the project's being placed on hold for a period of over one year. The project was revitalized in January of 1992 when it became apparent that the NASA scientific community was moving rapidly into multimedia publishing. This led the STI Program to recognize that it needed to rapidly develop a multimedia capabilities base in order to effectively perform its mission of disseminating information. The project plan was updated to reflect current Program direction, and three introductory subprojects were identified and prioritized.

#### Non-Print Project

The Non-print Project was given highest priority and consequently has received the most attention to date. The Non-print Project Plan was finalized in

November of 1992. This project will enable the STI Program to effectively handle non-print in an operational prototype mode in the first quarter of 1993. The Non-print project followed a standard information system design methodology. User requirements were gathered through a telephone survey and videoteleconferences with an advisory group with NASA-wide representation. The project has been proceeding according to plan and is ahead of projected completion date for several milestones. The initial focus of the Non-print Project is video material. As a result of this project, The STI Program's Center for Aerospace Information (CASI) will become the central repository for NASA-produced videos. The CASI will be able to archive and replicate videos for Program users on a mass basis as early as first quarter 1993. The NASA STI Program will provide handling and dissemination of other varieties of non-print on a more limited basis. The Program will also begin to serve as the source for videotapes of NASA Select television programs in 1993. In conjunction with the Non-print Project, STI Program staff members have participated in the CENDI Interagency Standards Working Group for the Handling of Video and Other Non-print STI. This group has recently completed a set of guidelines for non-print information that details items such as minimal acceptable quality, packaging, etc.

#### Performance Support System

The Performance Support System Project Plan was completed in January, 1992. The Performance Support System will utilize a rapid prototyping methodology to provide comprehensive information support at the desktop to STI Program staff members. As defined by Gloria Gery, a performance support system authority, an electronic performance support system is an integrated electronic environment that is available to and easily accessible by each staff member and is structured to provide immediate, individualized on-line access to the full range of information, software, guidance, advice and assistance, data, images, tools, and assessment and monitoring systems to permit job performance with minimal support and intervention by others. The STI Performance Support System project extends this definition to include animated images, full motion video, the presentation of information from different perspectives, and simulation that can portray and test conflicting theories. This project is currently entering the design stage where the details of carrying out the project plan will be defined. Central to the concept of the STI Program Performance Support System is the fact that few people prefer to read text from the current generation of computer screens. Thus, the project

emphasis is based on the fact that seeing images and hearing sounds is the natural way for people to receive information. This project will provide an initial proof-of-concept for delivery of multimedia information to users within the STI Program framework. The timeline for the project will begin after the arrival of the development hardware and software that will be discussed later. A later phase of the project will extend the initial prototype to provide performance support for NASA scientists in a specific discipline. The discipline of choice will be determined in conjunction with the STI Program User's Group.

### Global Change Project

The NASA STI Program Global Change Project is the newest of the STI Program Multimedia Initiative projects. The current project activity is centered upon user discussions and development of a comprehensive project plan. Although this project is still on the drawing board, it also has the greatest potential for benefit through multimedia information delivery. This is because global change data includes measurements from multiple instruments both simultaneously and over time. Researchers say that these disparate data each reveal some aspect of a physical phenomenon. Further study of such data may involve combining the data with empirical models or numerical simulations. In addition, correlative data analysis both implies looking at different data sets in the same way and requires multiple ways to study the same or different data. Visualization of earth science data such as global change data sets provides the researcher with a key to understanding multiparameter data sets.<sup>7</sup> Such information can be further enhanced through the use of multimedia. Rather than viewing one or several videos, dealing with simulation software, viewing images and data, and reading a technical report, the researcher can be presented with the information as a unified whole through the use of multimedia. Alternately, as technology advances, the researcher could be provided with a comprehensive fully immersive virtual reality system.

The STI Program Global Change projects goal is to provide global change information in multimedia format to university level and beyond researchers. The project concept is based on the premise that multimedia can add value and foster understanding of global change data. In addition, the huge volume of global change information available can be made more accessible to researchers through an easily navigable multimedia user interface. The first phase of this project will deliver a prototype multimedia global change information system that will demonstrate the

value to be added by multimedia delivery of selected global change information. The follow-on phase could address a comprehensive global change system that will benefit university students and professional researchers. This project would utilize a global change content advisor and user outreach specialists in addition to the regular project team members. Discussions with industry multimedia developers who have expressed interest in a joint venture for this project are underway.

### Multimedia Project Development Team

The NASA STI Program Multimedia Project Development Team to date includes two individuals with expertise in video production, one individual with graphics production expertise, one with communications and marketing expertise, and one with project management and computer programming expertise. Although one often reads of the difficulty multimedia project teams have in communicating with each other, this has not been a problem thus far. However, it is interesting to note the vastly different perspectives that the team members bring to the effort that clearly arises from the different disciplines and business cultures from which they come. As is often the case, the video people clearly emphasize content, which is of primary importance in a multimedia application, whereas the computer programmer may be overheard mentioning time-based video data. The group is working to make their differing backgrounds an asset to the project so that they can pull together to deliver effective STI Program multimedia applications.

### Challenges

As with most new information technology applications, the NASA STI Program Multimedia Initiative is facing a number of difficult challenges that can impact the success of the project. To date, some of the challenges have been overcome, but others still present difficulty.

### Cultural and Organizational

The most immediate challenge to the introduction of multimedia technology into the STI Program was encountered at the Multimedia Initiative project's birth. In order to begin work on the project after it was conceptualized, the project had to be marketed within the STI Program because staff who were oriented to work with paper-based information needed to reconsider their job functions. Staff members ran the gamut from early adopters of new technology to those who were not yet truly comfortable with the office automa-

tion network that had been introduced several years ago. In the middle was a large group that was quite comfortable with the way things were and was not able to see the value of committing program resources to something that appeared to be a futuristic technology like multimedia. The initial efforts at marketing the Multimedia Initiative internally did not succeed and the resources necessary to go forward with the project were not allocated. However, the early Multimedia Initiative staff members were confident that multimedia technology would be required by the Program in the short-term and continued to make the case. Eventually after multiple documents, conference presentations, and attempts at robust cost-benefit analyses, the project appeared to be gaining momentum. The real keys to gaining staff support were presentations from several NASA Centers showing that they were moving into multimedia rapidly coupled with a demonstration of the very successful multimedia application, "Columbus." These items marked a turning point and during the next budget iteration, limited funding was made available for the project.

As the Multimedia Initiative and its subprojects have progressed, the availability of project implementation plans and standard information system life cycle documentation fitting the design framework reference model has served to lend credibility to the Multimedia Initiative suite of projects. It is as though the presence of familiar documentation made these somewhat unfamiliar projects acceptable to traditional system designers.

#### Standards

There is currently no standard for multimedia since it is the blending of many different technologies provided by a diverse group of vendors from the very different market areas of computers and home electronics. However, the Interactive Multimedia Association (IMA) began an Interactive Multimedia Association Committee Compatibility Project in 1988 to develop recommendations that would permit multimedia applications portability across a variety of hardware/software platforms. The committee began by focusing on interactive video applications in the MS-DOS environment with the objective of later expanding their initiatives to other operating systems and multimedia technologies. The IMA Compatibility Project has formed a number of committees to address specific compatibility issues.<sup>3</sup>

Other groups such as the Institute of Electronic and Electrical Engineers Computing Society (IEEE/CS) are

also addressing compatibility issues. However, in today's marketplace, the purchaser of multimedia equipment cannot expect to play applications developed on other systems. There has been a history of the successful porting of applications by developers from MAC to PC, and there are a few interactive multimedia application authoring systems that facilitate such transfer, but in the current marketplace, one cannot expect to interchange multimedia information.

The standards issue became a major challenge for the STI Program Multimedia Initiative because lack of standards meant that the development platform choice would also dictate the delivery platform choice. Results of the NASA STI Program user survey indicated that providing initial applications that could run on both Macintosh systems (MACs) and IBM or IBM compatible Personal Computer Systems (PCs) would be appropriate for the Program user community, with later development planned to be available on SUN systems as well. Although the staff developed a capabilities matrix for the systems available at the time, the important issue of which system would gain the most users over time could not be addressed because there was no way to predict with certainty which competing multimedia format would become the de facto standard. Even so, the STI Program development platform was chosen shortly after the project was revitalized in January of 1992. At that time, there were multiple multimedia platform development choices, some of which were geared toward very different end-user markets. Apple had not yet released its QuickTime extension to the Macintosh system software, and the Motion Picture Experts Group (MPEG) compression standard was still being defined. New product releases and product retirements were the order of the day. In the eyes of the Multimedia Initiative project staff members who were choosing the system components, a more volatile marketplace would be impossible to find.

In spite of the volatile marketplace and the lack of standards, the Multimedia Initiative staff applied a modified version of the High Technology Man-Machine Performance Evaluation Plan (HTPE), developed at Lawrence Livermore National Laboratory, to the multimedia hardware/software selection process and made a recommendation that specific hardware and software be procured initially with later procurements to follow as the marketplace settled. The initial hardware and software chosen is minimal but fits within the budget and is being purchased with the understanding that an additional procurement will come later. In several cases, hardware or software has been retired or superseded by newer products. In such instances, the replacement item is presented in the table. All components will not necessarily reside on the same computer.



Table #3

## STI Program Multimedia Components

Hardware	Key Software
Apple Quadra 950 with 32 Mb RAM, 2 Mb VRAM, 1.2 Gb External Hard Disk	Macromind Suite of Products including Director, Accelerator, 3-D, Mediamaker, etc.
	System 7.0 QuickTime
Raster Ops 24 Bit Monitor	*Authorware Professional
NEC Double-Speed CD-ROM Drive	Adobe Premiere
Raster Ops Espresso Professional Slide Scanner	
New Video EyeQ Capture/ Delivery System	
Video Spigot	
NEC PC VCR	
Kodak Digital Camera System	
MacSpeakers	

\* Chosen for application portability between Mac & PC

As this paper is written, the long-awaited system components are just beginning to arrive at the STI Program offices. The earlier observation about the volatility of the marketplace has been realized since most major system components have been replaced with newer items over the course of the procurement.

#### Networking Multimedia

The Multimedia Initiative project team recognizes the need to provide networked multimedia applications.

Application development would be helped by allowing team members to share components of the development system. Although networking multimedia at the Local Area Network (LAN) level has been accomplished by groups such as Starlight Networks, the STI Program's LAN is built upon Ethernet segments and shared bandwidth. The current system cannot support multiple streams of video information. Although the project team can develop initial applications without benefit of network information exchange, the success of the Performance Support System will hinge upon the ability to deliver the information over the LAN. Since the current LAN is scheduled to be replaced in the next year, networked multimedia may be in the STI Program's future. Although not mentioned previously, a key to successful networking is compression of video data. Even with a 50:1 compression ratio, delivery of 24 bit color at 30 frames per second (NTSC full motion video) requires a 15 Mbit/sec bandwidth. If multiple users require video information, the LAN must be able to support the aggregate bandwidth. LANs now have greater bandwidth than available wide area networks. T1, for instance, has a bandwidth of 1.544 Mbits/sec. Although the Multimedia Initiative would like to deliver multimedia information over wide area networks, it appears that the Initiative will have to wait for the National Research and Education Network (NREN) to accomplish this.

#### Intellectual Property Rights

The STI Program Multimedia Initiative will heavily utilize NASA and other Government-produced information resources that are not copyrighted. So, intellectual property rights are not likely to present as great a problem as for others involved in multimedia. The Initiative must still deal with the fact that copyright laws apply to visuals, sound, software, and any other material that belongs to someone else. The procedures for gaining rights to material such as video clips or music differ from those of software and print publications. Also there is some question as to the scope of the rights once granted. Do the rights extend to "publication" in a multimedia application? Questions regarding intellectual property rights and multimedia are just beginning to be addressed. According to COMDEX/Fall '91 "Intellectual Property: Issues and Challenges in Multimedia" session panelist, Gervaise Davis III, "Every time a new technology comes along, there's a period of 10 to 15 years with litigation. It happened with movies. There was a whole series of cases when TV came along, then cable TV; now with videodiscs and CD."<sup>5</sup>

## The Vision

The STI Program Multimedia Initiative's goal is to have the NASA users gain the benefits that multimedia information delivery can provide. While we have discussed the advantages of a unified interface to multiple types of information, the ability to present information from different perspectives, the ability to combine data with empirical models or numerical simulations, and other benefits, the Program realizes that the Multimedia Initiative staff cannot anticipate all of the ways through which a multimedia information delivery system can be used to increase the effectiveness of information delivery to researchers within NASA and other organizations. That is why the Initiative is using the rapid prototyping method of development. This approach will allow our users to participate in our multimedia systems design through use and evaluation of the prototypes that will feed design changes. Thus, the details of our "Multimedia Initiative Vision" will be defined in an evolutionary fashion by our users.

In closing, there are some successful multimedia applications that we would like to share to allow you to make a personal assessment of the potential for multimedia. To date, there are not many scientific and technical information applications of multimedia. However, one application of note is the Arctic Data Interactive (ADI) CD-ROM prototype. ADI was produced by the U.S. Geological Survey (USGS) and includes data provided by Don Cavaliere of NASA Goddard. USGS calls this application a prototype hypermedia system. ADI includes animation and sound but no full motion video. The ADI disc was produced by the U.S. Geological Survey to stimulate discussion on new and innovative methods for disseminating global change data and information. It is a compendium of interdisciplinary information and data on the Arctic region. We acquired this disc in researching our Multimedia Initiative's Global Change Project.

There are many other multimedia applications that should be shared. We will mention a few of the many applications that cut across disciplines. There is the interactive disc on the Gulf War titled "Desert Storm" that was produced by a joint venture between Warner New Media and Time magazine. There are also several major applications supported by IBM including "Ulysses," "Hamlet," "Martin Luther King," the "Declaration of Independence," and the "American Indians." The Smithsonian Institution has been working on a networked educational multimedia application called "Classrooms Without Walls." It will

provide access to large databases of visual and audio information on a LAN.

IBM's "Columbus: A Journey to Discovery" is better seen than discussed. However, we will present a brief summary here for those who will not have an opportunity to view the application. Columbus is the first in IBM's Discoverers Series. IBM describes the Discoverers Series of programs as "seeking to provide navigational tools that allow teachers and students to explore interrelated materials from large databases of information."<sup>2</sup> IBM developed Columbus in conjunction with Robert Abel of Synapse Technologies. This multimedia application includes 180 hours of interactive material. According to Robert Abel, the program is not only about Columbus, but "it uses Columbus as a metaphor for a changing view of the universe."<sup>2</sup> According to Paul Evans of IBM, Columbus provides multiple points of view on its content and demonstrates "the complex interconnectedness of knowledge."<sup>2</sup> In considering this application, you can see some of the advantages of multimedia presentation. Join us in our vision by extending this application of technology to see the potential for multimedia in the incredibly rich universe of scientific and technical information.

## References

1. *A Strategic Direction*. NASA Scientific and Technical Information Program, Washington, D.C. 1991.
2. "IBM Presents Columbus and the Classics." *Multimedia & Videodisc Monitor*, May, 1991.
3. "IMA Compatibility Project Proceedings." Volume 1, Issue 1. September, 1991.
4. "Invision Multimedia Awards 1993 Call for Entries." *New Media: Multimedia Technologies for Desktop Computer Users*. November, 1992.
5. "Interactive Multimedia White Paper: Promise and Pitfalls." Knowledge Industry Publications, Inc. 1991.
6. Osborn, Hugh. "Media Computers, Motivation, and Informal Education: Gutenberg 2000?" *Learning with Interactive Multimedia: Developing and Using Multimedia Tools in Education*. Microsoft Press, Redmond, Washington. 1990.
7. Treinish, Lloyd. "Correlative Data Analysis in the Earth Sciences." *IEEE Computer Graphics & Applications*, May, 1992.